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Ferroelectric liquid crystals as optical polarization modulating media: at the present and future perspectives

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Light polarization is one of the key characteristics playing an important role in modern optoelectronics. Polarization properties of light are widely utilized in ellipsometry, polarimetry, remote control systems and many others. Nowadays, a number of materials for modulating optical polarization were tested and successfully employed. Among all of these materials, liquid crystals (LC) have some attractive properties such as low energy consumption, large aperture and relatively fast switching time. Among the LC, currently two main competitive technologies exist, namely nematic liquid crystals (NLC) and ferroelectric liquid crystals (FLC). The former one are widely used in Flat Panel Displays in a huge market. The latter one offers fast response time (in _s range) and in-plane rotation of the optical axis. Unfortunately, the FLCs are irreversibly sensitive to the external mechanical deformation which limits their application field. Additionally there are still some problems with structural defects.

This report is intended to demonstrate that performance of the FLC modulators can be greatly improved by both the modification of the FLC chemical structure and the changing of the properties of the confining substrates. These two approaches allow to enhance their electrooptical behavior and strengthen the mechanical stability. Finally some perspectives on were one can apply FLC will be discussed.

To avoid structural defects of the FLC textures and to improve their stiffness new FLC materials will be considered, either based on mixtures exclusively out of chiral smectic C compounds or on doping smectic C components with those chiral compounds, which are non liquid crystalline. Some examples will be demonstrated were the mechanical stability was improved. Upon application of mechanical shock, the FLC should relaxes preferably in the same manner as nematics, which would be ideal to combine good properties of nematics with the switching speed of FLC. More over, defect free prototypes over a broader area could be prepared. Therefore, we hope that our way will allow us to develop new mixture competitive in crucial parameters with commercially available nematics.

The other way to enhance the electrooptical properties of the FLC modulators is the modification of the cell substrate properties. It was showed that the thickness of the alignment/insulating layers played a crucial role for the electrooptical response of the FLC modulator. Due to the voltage divider formed by these layers and liquid crystals, the form of the voltage applied to the FLC is different from those applied to the whole cell. If the impedance of these layers satisfies some optimal conditions (e.g. thick alignment layers) the electrooptical response will be thresholdless and hysteresis free. The computer modeling and our experimental results confirm this approach and allowed us to increase the inversion frequency up to more than 1 kHz. In this case, one can observe other interesting effect, that is, if one apply driving voltage with very high frequency, the response time of such modulators also greatly decreases.
From the other side, as it was showed by us, under just opposite conditions (e.g. thin and conductive alignment layers), the electrooptical response will be bistable.

Along the third part of the report, new horizons of using FLC materials will be discussed. Their utilization in present and perspective devices will be outlined. Because of the fast switching time the applications of FLC for polarization controlling and correcting, in microwave engineering, in photonic crystals, as fast switchers and many others are very attractive.

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